In the Specification:

Please amend the specification as follows:

Page 1, line 7 to page 2, line 19.

BACKGROUND OF THE INVENTION

Increasing volumes of communications traffic are now being carried on packet networks, and in particular on Internet Protocol (IP) networks. Such networks comprise ~~on any~~ nodes or routers interconnected by links so as to define a mesh. A recent introduction has been the concept of a network having an optical core in which traffic is carried on switched optical fibre paths between routers. The core is accessed by an edge network. Typically in the design of high capacity IP networks, routers are classified as either core routers or edge routers. Edge routers carry out all the network ingress and egress functions, in particular controlling the incoming traffic streams across the network. Core routers act as transit routers forwarding network traffic from one network node to another.

In such a network, the user data is assembled into packets and each packet is provided with a header identifying the destination of the packet and optionally, including routing information. The header may further contain information relating to the router ~~of~~ chosen to route the packet contents and identifying a priority class for the packet. For example, packets containing high quality of service real time traffic, ~~and is~~ such as voice, will be accorded the highest priority, while packets containing 'best efforts' data may be accorded a low priority.

A particular problem that has been experienced with certain types of traffic, particularly data traffic and real-time video traffic, ~~in~~ is its inherently bursty nature. Further, this burstiness occurs on a timescale that is shorter than feasible network control loop timescales, and thus can lead to congestion when traffic is heavy. When congestion occurs, ordinary data traffic which is not critically time sensitive can be briefly buffered in the routers which are experiencing congestion. Urgent data traffic and real time interactive services such as voice and video cannot be delayed.

In order to maximise the overall network utilisation, it is desirable to perform statistical multiplexing of traffic traversing the network while providing a prior allocation of resources and protection particularly for the delay sensitive traffic . Existing control and feedback mechanisms ~~Such as described in patents...~~ are however inadequate to respond to this bursty traffic at a sufficiently rapid rate to provide this resource allocation and protection. In the conventional approach to this problem, the high speed statistical variations in traffic flow are simply allowed for by setting large margins in the setting of control levels for determining feedback price. Proposals for 'pricing' ingress flows at the edge of the network for admission control purposes have involved for instance measuring the 'effective bandwidth' of the flow. ~~(Ref)~~ Effective bandwidth is a measure of the bandwidth that needs to be reserved to give a desired packet loss ~~or~~ for delay rate on a statistically varying flow. Unfortunately, effective bandwidths do not add linearly on aggregation and so are difficult to use in a congestion price feedback control scheme.

Page 3, lines 3 to 12.

According to another aspect of the invention, there is provided a method of controlling admission of traffic flows to a communications network, the method comprising sampling the traffic flows ~~each~~ at an ingress, and sampling an aggregate flow of said flows at some or all of the resources used by the aggregate flow, determining from said sampling a mean bandwidth requirement for each traffic flow and a measure of the variance from that mean, determining from said mean and variance measurements first and second prices for the mean and variance components of the controlled traffic flows that are admitted to the network, and determining from said first and second prices an admission cost for each said flow so as to regulate the admission of that flow.

Page 4, line 20 to page 7, line 5.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring first to Figure 1, this shows an exemplary network in schematic form. As shown in Figure 1, the network comprises a number of nodes 11, 11a interconnected by links 12. As shown in Figure 1, the network comprises a core region 13 accessed via an edge region 14. The links 12 are usually optical fibre links, particularly in the core region. Advantageously the network of Figure 1 is an Internet Protocol (IP) or MPLS (multi protocol label switched) network in which traffic is transported in packet form. An objective of the resource control system is to control the ingress of IP and MPLS traffic in such a way that different traffic classes are treated optimally. In particular, delay sensitive classes of traffic must see minimal congestion inside any router or on entering any of the packet buffers at the entrance to each optical link.

Referring now to Figure 2, this shows in schematic form a an edge node 11 and a core network node 11a. At the edge node 11, a number of input traffic flows are aggregated on to a traffic path on link 12. At the core node 11a two transit traffic flows are shown merging. Prior to entering the packet buffer 17 at the entrance to transmission link 12, the traffic is sampled by the aggregate sampling circuit 21. At the entrance to the next link 12a on the traffic path 12a a similar measurement arrangement of packet buffer 17a and aggregate sampling circuit 21a exists ~~17a,21a~~. The traffic flows are sampled by sampling circuits 21 and ~~22~~ 21a to determine both the mean bandwidth usage x_i and the standard deviation σ_i from ~~that~~ the mean for each aggregated flow across the network. The mean and standard deviation measurement are processed by a network admission controller to determine a pair of prices for using that particular resource. This price pair defines separate prices for the mean component of traffic flow and the deviation (or variance) component. A separate ingress controller 23 (Figure 2a) in the edge router has a sampler 24 that samples 24 and measures the mean and deviation of individual edge to edge flows entering the network. The ingress controller also continuously monitors the sum of the resource price pairs for the edge to edge path it is using. (note there is one ingress controller per edge to edge path, the explicit edge to edge path being defined for instance by MPLS labels attached to each packet. The user (or a software object using pre-agreed ingress control rules) can then either accept this price or modify this mean bandwidth or standard deviation bandwidth requirements to obtain his optimum quality of service vs price. To modify the ingress traffic flow the ingress controller could use the a traffic shaper 25 (figure 2a) or for example send a signal back to the original traffic source (not shown). The traffic shaper controls a scheduler 26. This price feedback mechanism provides a self-regulating mechanism on the bandwidth demands imposed on the network.

The ingress controller 23 controls traffic on every end to end path through the network. The paths may be MPLS paths.

Referring now to Figures 3a and 3b, these illustrate respectively idealised and practical bandwidth requirements for a traffic flow. Figure 3a shows a slowly varying mean bandwidth demand, while figure 3b shows a typical rapid short term variation superimposed on the mean.

The short term variations, which represent the deviations of the traffic flow from the mean, are illustrated in Figure 4. These can be statistically analysed in real time to give a measure of mean and standard deviation. This analysis also gives the variance which is the square of the standard deviation squared. A variety of algorithms could be used for this purpose. The exponentially weighted time averaged mean is one of the simplest, whilst the sampled data ~~can~~ and the mean together can be used to give the time averaged variance. The rest of this description makes the assumption that the sampling periods and rate and time averaging parameters used for ingress control purposes are sufficiently similar to those used by the aggregate flow meters that insignificant errors are caused. Typically the time averaging time constant is greater than the feedback time constants of the DRC control system. Typically 100ms to 10 seconds. The variance sampling period is typically sufficiently short that the shortest bursts ~~you are~~ one is interested in controlling are captured. This implies that a sampling time period does not need to be much shorter than the specified worst case permitted delay variation for the traffic being controlled. 1-10ms (milliseconds) might be appropriate for typical delay sensitive traffic. (Longer sampling periods could be tolerated if margins were increased. A measure of the significance of these rapid short term variations is given by the standard deviation (σ) or by the corresponding variance σ^2.

In the arrangement of Figure 2a in which a number flows are aggregated on a common path~~. A~~, assuming that traffic deviations are uncorrelated in time, the standard deviation σ_A of the aggregate flow is given by the expression

$$\sigma_A = \sqrt{\sum \sigma_i^2}$$

The aggregated mean traffic of course adds linearly so the aggregated mean flow and is given by the expression

$$x_A = \sum x_i$$

Referring now to Figure 5a, this illustrates a bandwidth plan from which pricing information is determined to provide feedback control for admission to the network. In figure 5a, the network operator sets a peak bandwidth maximum or control level x_c which, in the ordinary ~~cause~~ course of events should not be exceeded, even momentarily by the peak bursts of the aggregated traffic. A typical flow has a mean bandwidth x_A well below this maximum level. Further, to minimise the risk of congestion, this mean x_A should be at least one and preferably 'k' standard deviations below this control level x_C. To ensure that the probability of momentary congestion is sufficiently small for all practical purposes k should typically lie in the range 3 to 6.

<u>Page 10, lines 1 to 9</u>

For optimum resource usage in a future system in which the ingress controllers actively adjusted the shaping of the mean and deviation components of their traffic in response to mean and deviation prices and the class of traffic being transmitted, then maximum user utility would be obtained when proportional fairness is applied to the allocation split between mean and deviation traffic. The resource would thus adjust the ratio of x_{CM} to x_{CD} to be the same as the current revenue from mean traffic and the current revenue <u>from</u> the variance component of the traffic. These adjustments would have to be carried out slowly in comparison to the DRC feedback control time constant or instability could result.